

We claim:

1. A method of making a crosslinked polymer comprising the steps of:
 - a) providing a highly fluorinated fluoropolymer comprising: a backbone derived in part from tetrafluoroethylene monomer, first pendent groups which include a group according to the formula $-\text{SO}_2\text{X}$, where X is F , Cl , Br , OH or $-\text{O}^-\text{M}^+$, where M^+ is a monovalent cation, and second pendent groups which include a halogen atom selected from the group consisting of Br , Cl and I ; and
 - b) exposing said fluoropolymer to electron beam radiation so as to result in the formation of crosslinks.

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2. The method according to claim 1 wherein said method additionally comprises, prior to said step b), the step of:
 - c) forming said fluoropolymer into a membrane.

15 3. The method according to claim 1 wherein said membrane has a thickness of 90 microns or less.

4. The method according to claim 1 wherein said step of exposing said fluoropolymer to electron beam radiation comprises exposing said fluoropolymer to greater than 1 Mrad of electron beam radiation.

20 5. The method according to claim 1 wherein said step of exposing said fluoropolymer to electron beam radiation comprises exposing said fluoropolymer to greater than 3 Mrad of electron beam radiation.

25 6. The method according to claim 1 wherein said step of exposing said fluoropolymer to electron beam radiation comprises exposing said fluoropolymer to greater than 15 Mrad of electron beam radiation.

30 7. The method according to claim 1 wherein said highly fluorinated fluoropolymer is perfluorinated.

8. The method according to claim 1 wherein said pendent groups are according to the formula $-R^1-SO_2X$, where R^1 is a branched or unbranched perfluoroalkyl or perfluoroether group comprising 1-15 carbon atoms and 0-4 oxygen atoms, and where

5 X is F, Cl, Br, OH or $-O^-M^+$, where M^+ is a monovalent cation.

9. The method according to claim 1 wherein said pendent groups are groups according to the formula $-O-(CF_2)_4-SO_2X$, where X is F, Cl, Br, OH or $-O^-M^+$, where

10 M^+ is a monovalent cation.

10. The method according to claim 1 wherein said pendent groups are groups according to the formula $-O-(CF_2)_4-SO_3H$.

11. The method according to claim 1 wherein said halogen atom included in said

15 second pendent groups is Br.

12. The method according to claim 8 wherein said halogen atom included in said second pendent groups is Br.

20 13. The method according to claim 2 wherein said pendent groups are according to the formula $-R^1-SO_2X$, where R^1 is a branched or unbranched perfluoroalkyl or perfluoroether group comprising 1-15 carbon atoms and 0-4 oxygen atoms, and where

15 X is F, Cl, Br, OH or $-O^-M^+$, where M^+ is a monovalent cation.

25 14. The method according to claim 2 wherein said pendent groups are groups according to the formula $-O-(CF_2)_4-SO_2X$, where X is F, Cl, Br, OH or $-O^-M^+$, where

15 M^+ is a monovalent cation.

15. The method according to claim 2 wherein said pendent groups are groups according to the formula $-\text{O}-(\text{CF}_2)_4\text{SO}_3\text{H}$.

16. The method according to claim 2 wherein said halogen atom included in said 5 second pendent groups is Br.

17. The method according to claim 3 wherein said halogen atom included in said second pendent groups is Br.

10 18. The method according to claim 3 wherein said pendent groups are according to the formula $-\text{R}^1\text{SO}_2\text{X}$, where R^1 is a branched or unbranched perfluoroalkyl or perfluoroether group comprising 1-15 carbon atoms and 0-4 oxygen atoms, and where X is F, Cl, Br, OH or $-\text{O}^-\text{M}^+$, where M^+ is a monovalent cation.

15 19. The method according to claim 3 wherein said pendent groups are groups according to the formula $-\text{O}-(\text{CF}_2)_4\text{SO}_2\text{X}$, where X is F, Cl, Br, OH or $-\text{O}^-\text{M}^+$, where 20 M^+ is a monovalent cation.

20. The method according to claim 3 wherein said pendent groups are groups according to the formula $-\text{O}-(\text{CF}_2)_4\text{SO}_3\text{H}$.

21. The method according to claim 3 wherein said halogen atom included in said second pendent groups is Br.

25 22. The method according to claim 18 wherein said halogen atom included in said second pendent groups is Br.

23. The method according to claim 4 wherein said pendent groups are according to the formula $-\text{R}^1\text{SO}_2\text{X}$, where R^1 is a branched or unbranched perfluoroalkyl or

perfluoroether group comprising 1-15 carbon atoms and 0-4 oxygen atoms, and where X is F, Cl, Br, OH or $-O^-M^+$, where M^+ is a monovalent cation.

24. The method according to claim 4 wherein said pendent groups are groups

5 according to the formula $-O-(CF_2)_4-SO_2X$, where X is F, Cl, Br, OH or $-O^-M^+$, where M^+ is a monovalent cation.

25. The method according to claim 4 wherein said pendent groups are groups according to the formula $-O-(CF_2)_4-SO_3H$.

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26. The method according to claim 4 wherein said halogen atom included in said second pendent groups is Br.

27. The method according to claim 23 wherein said halogen atom included in said

15 second pendent groups is Br.

28. The method according to claim 1 wherein step c) comprises imbibing said fluoropolymer into a porous supporting matrix.

20 29. The method according to claim 28 wherein said porous supporting matrix is a porous polytetrafluoroethylene web.

30. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 1.

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31. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 2.

30 32. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 3.

33. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 4.

34. A polymer electrolyte membrane comprising the crosslinked polymer made 5 according to the method of claim 5.

35. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 6.

10 36. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 7.

37. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 8.

15 38. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 9.

39. A polymer electrolyte membrane comprising the crosslinked polymer made 20 according to the method of claim 10.

40. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 11.

25 41. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 12.

42. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 13.

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43. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 14.

44. A polymer electrolyte membrane comprising the crosslinked polymer made 5 according to the method of claim 15.

45. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 16.

10 46. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 17.

47. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 18.

15 48. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 19.

49. A polymer electrolyte membrane comprising the crosslinked polymer made 20 according to the method of claim 20.

50. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 21.

25 51. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 22.

52. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 23.

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53. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 24.

54. A polymer electrolyte membrane comprising the crosslinked polymer made

5 according to the method of claim 25.

55. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 26.

10 56. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 27.

57. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 28.

15 58. A polymer electrolyte membrane comprising the crosslinked polymer made according to the method of claim 29.

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